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FARMERS' BULLETIN 1260

STORED-GRAIN PESTS

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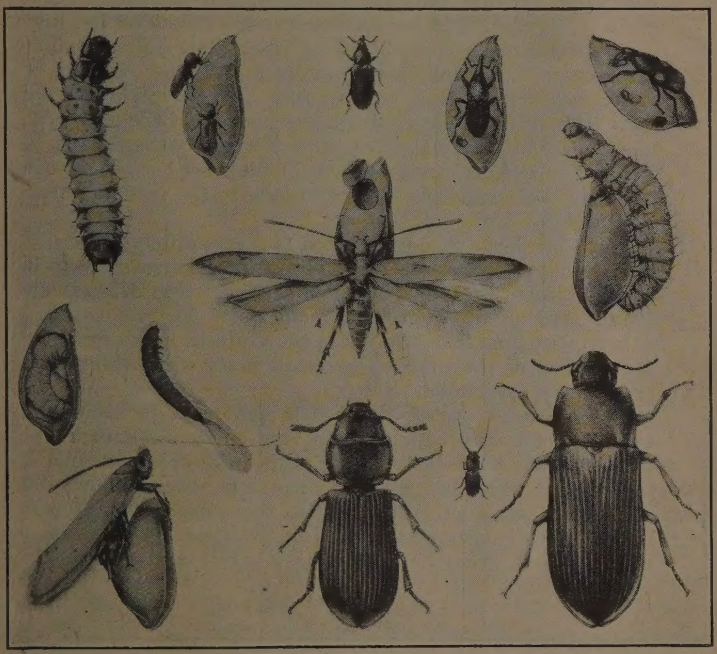

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MOST of the damage done by insects to grain in storage and shipments is due to four species. These are the granary weevil, the rice or black weevil, the lesser grain borer or Australian weevil, and the Angoumois grain moth. Others of the 40 species or groups of species described in this bulletin can cause great damage to grain if storage conditions are unusually favorable for their increase. Yet if grain in the unbroken kernel remains unaffected by the four insects mentioned, it is not likely, in commercial storage or shipments, to be sufficiently affected by other insects to cause appreciable loss. These four pests live throughout their larval life entirely within the kernel, where they feed unseen, usually unsuspected, and where they can not be reached by the ordinary methods employed by grain men in their grain-cleaning operations known to the trade as moving, fanning, and screening.

The other pests discussed, with few exceptions, are "surface feeders." Their larvæ may eat into kernels of grain and lie hidden there, yet the greater proportion of them are found feeding upon broken surfaces of kernels exposed either by mechanical injuries to the grain in handling or by the feeding of the four major grain pests with which they are usually associated.

The larvæ, or grubs, of the four major pests mentioned are not ordinarily capable of a free existence outside the kernel but the larvæ of the other grain pests are, in the main, capable of free locomotion, crawling where they will throughout grain in bulk, and are therefore susceptible to removal by fanning and screening. Methods of preventing infestation of grain and of treating infested grain are discussed briefly.

STORED-GRAIN PESTS.

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POPULAR CLASSIFICATION OF GRAIN PESTS.

Since the establishment of the Federal standards for grain under the provisions of the Grain Standards act, Federal grain supervisors and federally licensed grain inspectors are required to identify the various species of "live weevils and other insects injurious to stored grain" which may be present in the grain, and uniform names for grain insects should be used. Such uniform terminology will indicate definitely to all interested persons, including shipper, purchaser, and elevator operator, the exact nature of the insect found. Of the four major pests, the granary weevil, the rice or black weevil, and the lesser grain borer may be well called "grain weevils." The fourth of the major pests, the Angoumois grain moth, so destructive to wheat and corn, may be called "grain moth." Other insects likely to be found in any lot of grain may be called simply "beetles," "moths," and "mealworms," for their presence usually does not indi-

cate a condition likely to affect the trade, provided that after the grain has reached the elevator it is screened and fanned to remove these insects.

The writers have divided the insects discussed in this bulletin into grain weevils, grain borers, grain moths, flour moths, mealworms, grain and flour beetles, psocids, and mites. In some respects this is not a satisfactory grouping, especially for the insects listed as "grain and flour beetles," but it has the advantage of definitely placing the most serious insects troublesome in bulk grain.

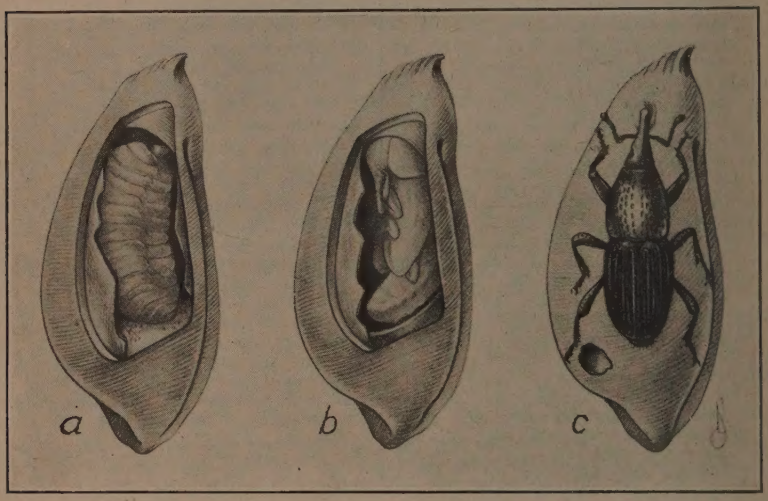

FIG. 1.—Life stages of the granary weevil in wheat: *a*, Well-grown larva; *b*, pupa; *c*, adult. Note hole in kernel made by the adult in order to leave the seed, and hole that it is eating into the kernel for the purpose of laying eggs. This weevil closely resembles the rice weevil but has no papery wings beneath its wing covers, and the dot-like punctures on the back behind its head are elongate rather than round.

GRAIN WEEVILS.

Of the four true weevils that attack grain in the United States only two are of primary importance at present, the granary weevil and the rice or black weevil. The broad-nosed grain weevil and the coffee-bean weevil are of minor importance except locally. These four weevils have an elongated beak or snout, as shown in the illustrations, though the beak of the coffee-bean weevil is greatly reduced.

GRANARY WEEVIL.[1]

The granary weevil (fig. 1) is a small, moderately polished, chestnut brown or blackish beetle with head prolonged into a long slender snout at the end of which are a pair of stout mandibles or jaws. It is

[1] *Sitophilus granarius* L.

not more than three-sixteenths of an inch long, and often smaller. It has no wings under its wing covers and the thorax is well marked with longitudinal punctures, two characteristics that distinguish it from the closely related rice weevil, with which it is often found associated. The well-grown footless whitish grub or larva and the pupa are shown at *a* and *b*, respectively, in figure 1. The granary weevil is one of the oldest known insect pests, is a universal feeder upon grains, and is cosmopolitan, having been carried by commerce to all parts of the world. It prefers a temperate climate and is more frequently found in the Northern States than in the South.

Both adult and larva feed voraciously on a great variety of grains. The adult weevils may live for 10 or more months, and during this period each female may lay from 200 to 300 eggs. Before laying her eggs the female bores a small hole in the grain berry with her snout. When this is made she turns about and lays in it an egg, which she then covers with a gelatinous fluid which seals the hole. The small white fleshy and legless grubs that hatch from the eggs burrow about inside the kernel. When full grown, the grub transforms to the pupa stage and then into the adult weevil. In warm summer weather the granary weevil requires about four weeks to pass through the egg, larva, and pupa stages and emerge as an adult of the succeeding generation. The period of development may be prolonged greatly by cold weather.

RICE OR BLACK WEEVIL.[2]

The rice or black weevil is a small snout-beetle which varies considerably in size but rarely measures more than one-eighth of an inch in length (figs. 2 and 3). It varies in color from reddish brown to nearly black and is usually marked on the back with four light reddish or yellowish spots. It closely resembles the granary weevil in form, but it has well-developed wings beneath its wing covers, differs in color and markings, and has the thorax densely pitted with round, instead of longitudinal punctures. Figure 2 gives a good impression of the appearance of the rice weevil and its earlier stages.

This weevil has been known from early times. It is found in all parts of the world where grain is used and is one of the very worst pests in stored grain. It is particularly abundant in warm countries, where it breeds continuously and rapidly destroys all unprotected grain. Throughout the South it causes tremendous losses to corn (figs. 4, 5, 6, and 7) and is the commonest of the serious pests of commercial grain shipments.

The adult weevil lives, on an average, four or five months, each female laying between 300 and 400 eggs during this period. The

[2] *Sitophilus oryza* L.

early stages are almost identical in habit and appearance with those of the granary weevil and need not be further described. The rice

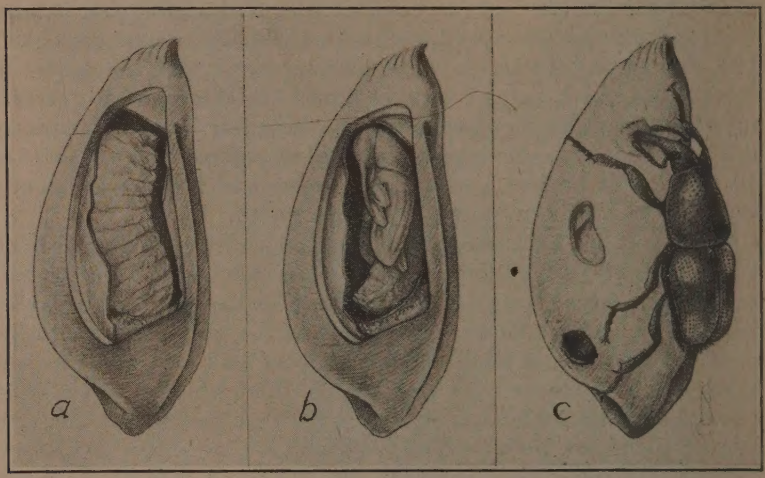

FIG. 2.—Life stages of the rice or black weevil in wheat: *a*, Well-grown larva; *b*, pupa; *c*, adult feeding upon kernel. Note in *c* the hole in lower portion of kernel made by the adult on leaving the seed, and at two points higher up shallow holes made by the adult in feeding upon the seed after emergence. The adult weevil is at once distinguished from the granary weevil, shown in figure 1, by the four light reddish brown or yellow spots on its wing covers, by the possession of wings beneath the wing covers, and by the many rounded punctures on the back behind its head.

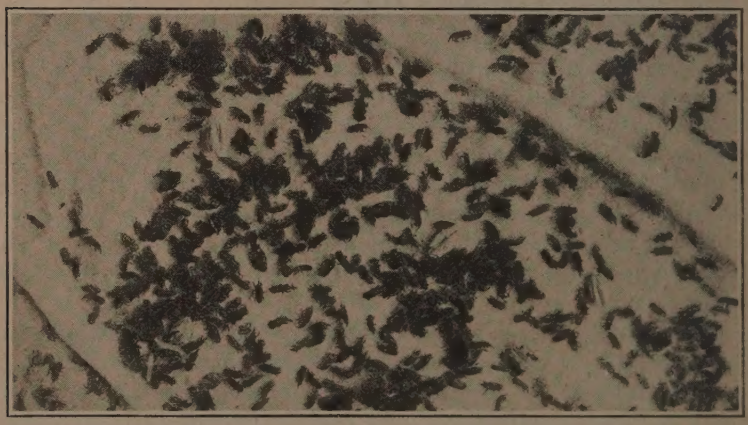

FIG. 3.—The rice or black weevil: Many adult weevils caught in the mesh of a cloth sack containing pearled barley. Compare their size with that of the barley kernels. Adult weevils when disturbed usually "play possum," but if spread upon a cloth in the sun the live ones will soon show signs of life.

weevil is a strong flier. The adults fly from granaries to the fields of grain and there start the infestation that often proves so disastrous after the grain has been harvested. During summer weather

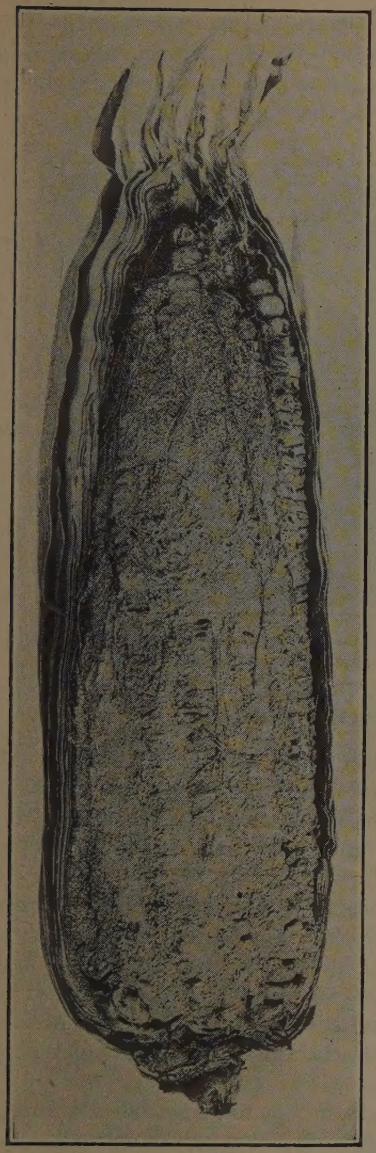

FIG. 4.—Ear of corn with a poor, loose shuck. It is badly infested with rice or black weevils. As the adult weevils feed, they push from the kernels the chewed-up portions, frass, etc., and this material, resembling white dust, collects in larger quantities between the kernels and the shuck, or, if the ears are shucked, it falls like powder onto any object below the ear. (Back.)

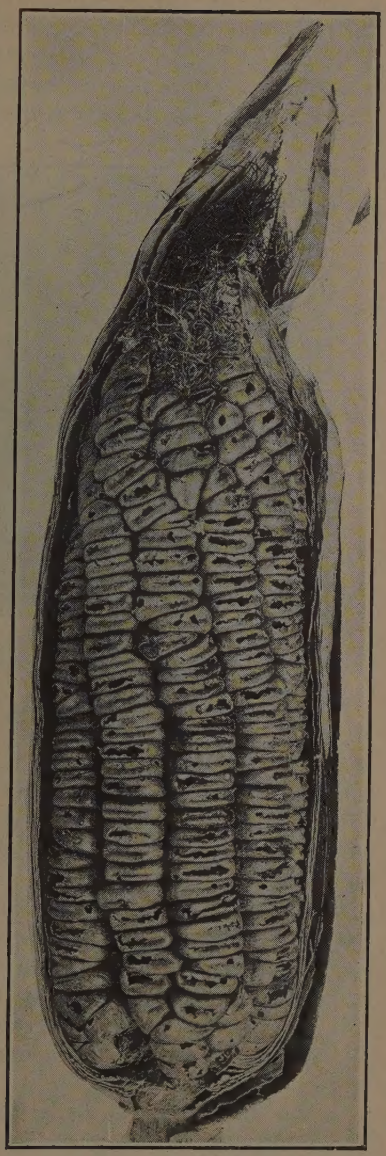

FIG. 5.—An ear of corn badly damaged by rice or black weevils. This ear has been hit against a table to jar loose the powdery substance, sometimes called the farinaceous material, and so reveals the great damage done by the weevils. The kernels of the ear have been reduced to powder and shell. (Back.)

the egg, larva, and pupa stages may be passed in as few as 26 days. This period, of course, is greatly prolonged during cool or cold weather. For a further discussion of this pest see Farmers' Bulletin 1029, United States Department of Agriculture.

FIG. 6.—Kernels of corn taken from badly infested ear corn, showing how the rice or black weevils can thoroughly destroy all parts of the kernels. (Back.)

BROAD-NOSED GRAIN WEEVIL.[3]

The broad-nosed grain weevil is a small dark-brown snout-beetle slightly less than one-eighth of an inch long. In form and color it resembles the granary weevil somewhat but differs from it and other grain-infesting weevils by having a short, broad snout (see figure 8.)

This weevil is occasionally found in Georgia and South Carolina and is wide-spread in Florida, where it is a serious pest of stored grains. It is unable to breed in dry, hard, uninjured grain, but attacks soft or damaged grain, or grain that has been attacked by other grain insects. It is a strong flier, and, like the rice weevil, flies to the cornfields and infests the grain before it becomes fully hardened.

The adult weevils normally live for about five months, and during this time the females lay between 200 and 300 eggs. The small white eggs are usually laid in broken portions of the grain. They hatch in a few days, and the small, white, legless grubs feed on the softer portions of the grain until they become fully grown. They then change to a white pupal form which in a few days transforms to the

[3] *Caulophilus latinasus* Say.

adult beetle and cuts its way out of the grain. The period from egg to adult in summer is about one month.

COFFEE-BEAN WEEVIL.[4]

The coffee-bean weevil is a very active, robust beetle from two-sixteenths to three-sixteenths of an inch long; dark brown in color, clothed with a mottled light and dark-brown pubescence. It may be easily recognized from the accompanying illustration (fig. 9).

This weevil is found in many countries and is extremely abundant in the Southern States, where it breeds in dried fruit, coffee berries, cornstalks, corn, and the seed and seed pods of an almost endless variety of plants. It is a strong flier and is frequently to be seen in the cornfields of the South on the exposed and damaged ears. It lays its eggs in the soft kernels of corn and breeding continues after the corn has been harvested and placed in storage. It does not cause much damage to corn in storage, as the corn becomes too hard to be attractive. It may, however, be very abundant locally in corn in Florida during the first three months of storage, and has been reported as comseeds in Honolulu. Taking the country at large, the coffee-bean weevil is a very minor grain pest. Figure 10, *a* and *b*, shows the rather characteristic holes cut in the kernels of corn and in corn shucks by the larvæ and emerging adults.

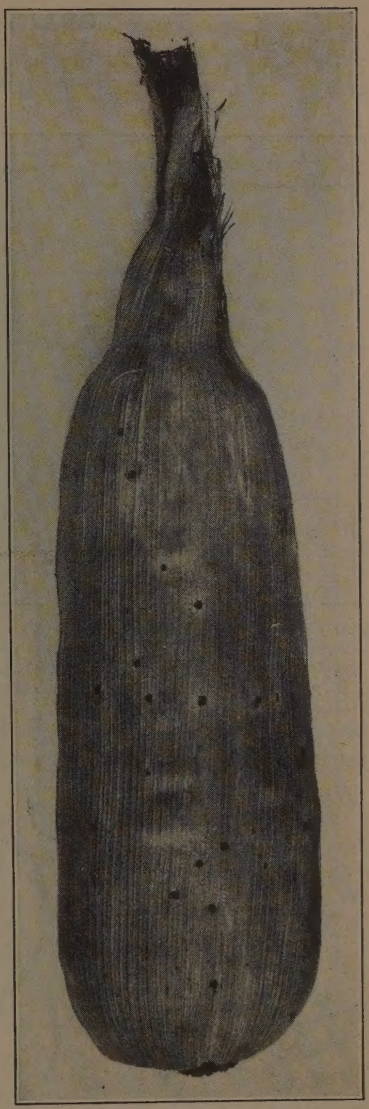

FIG. 7.—Slip-shuck corn showing holes eaten through the shuck by the rice or black weevil. These holes make passages through which all kinds of grain pests move back and forth to bring about a more speedy destruction of the kernels. (Back.)

[4] *Araecerus fasciculatus* DeG.

GRAIN BORERS.

Two species of grain borers are now established in the southern States. The *lesser grain borer* bids fair to become a very serious

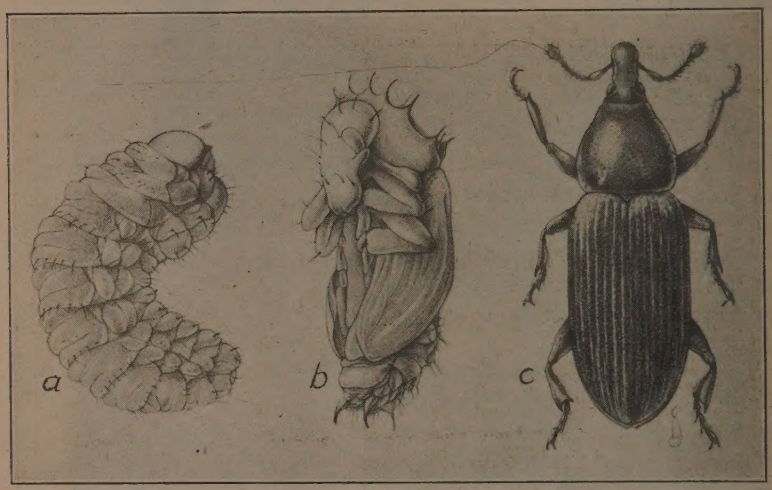

FIG. 8.—The broad-nosed grain weevil: *a*, Full-grown larva; *b*, pupa; *c*, adult weevil. This weevil is not found in northern-grown grains. It is now present in the southeastern Gulf States. The adult weevil is slightly less than one-eighth of an inch long. It is distinguished from the rice and granary weevils by its much shorter beak.

pest of grain throughout the South. The *larger grain borer* has not yet become a factor in commercial shipments of grain.

FIG. 9.—The coffee-bean weevil: *a*, Adult; *b*, well-grown larva; *c*, pupa. The adult is about three-sixteenths of an inch long, of a dark brown color covered with a light and dark brown hairiness. (Chittenden.)

LESSER GRAIN BORER.[5]

The lesser grain borer, known to many grain dealers more popularly as the "Australian wheat weevil," because of the large supplies of wheat infested by it that reached this country from Australia during the war, is one of the smallest beetles injurious to grain in this country. It appears to be steadily spreading throughout the South, and infested grain

[5] *Rhizopertha dominica* Fab.

has been found in Texas, Kansas, Oklahoma, Louisiana, Florida, and California, besides at many points of entry. It is readily distinguished from other grain pests by its slender cylindrical form and small size. It is a polished dark brown or black in color, with a

FIG. 10.—Work of the coffee-bean weevil: *a*, Holes made in corn shucks by the adult weevils eating their way out from the kernels beneath; *b*, two kernels in which larvæ of this insect have developed. Note that a single larva devours a large portion of a single kernel, which is not true of the rice weevil.

somewhat roughened surface, about one-eighth of an inch long and one thirty-second of an inch wide. Its head is large, prominent, and bent down under the thorax. The larva, pupa, and adult stages are illustrated in figure 11. It belongs to a family[6] of beetles that have

[6] Bostrychidae.

the head turned down under the thorax and are armed with powerful jaws with which they can cut directly into wood. Originally native

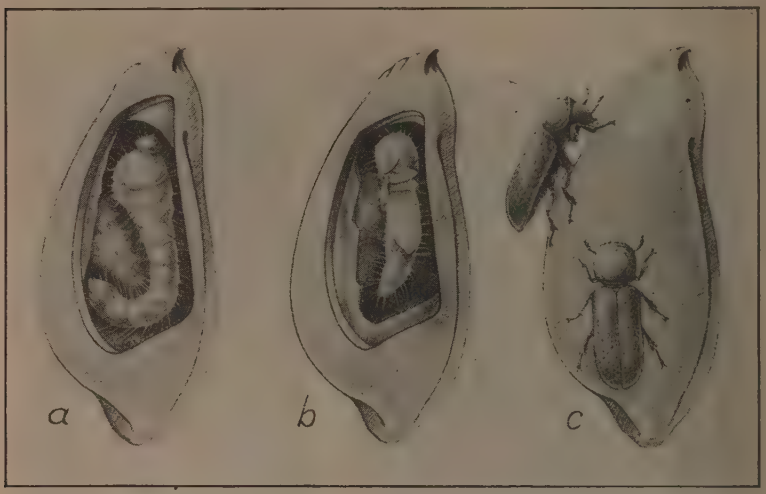

FIG. 11.—The lesser grain borer in wheat kernels: *a*, The well-grown larva; *b*, the pupa; *c*, two adult weevils. Adult borer is shiny roughened dark brown or black, about one-eighth of an inch long.

to the tropics the lesser grain borer has spread through commerce to all parts of the world.

Both beetles and larvæ cause serious damage in warm climates, attacking a great variety of grains. The destruction of which they

FIG. 12.—Kernels of wheat thoroughly riddled and devoured by the boring and feeding of the lesser grain borer and its larva. Such damaged kernels are always surrounded by much powder or flour-like material which the insects have chewed up and pushed out from the kernels.

are capable is shown by the wheat kernels of figure 12, which are literally riddled by the boring adults and their young. The females

lay from 300 to 500 eggs each, dropping them singly or in clusters in the loose grain. The eggs hatch in a few days and the small whitish grubs crawl actively about the grain, feeding on the flour produced by the boring of the beetles, or boring directly into grains that have been slightly damaged. They complete their growth within the grain, transform to white pupæ, and in time change to adult beetles which cut their way out of the grain. The period from egg to adult in summer is said to be about a month.

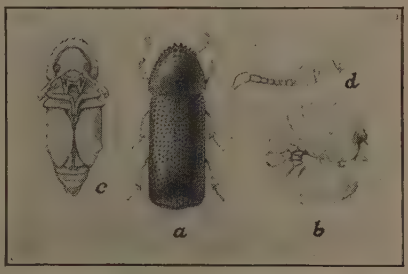

FIG. 13.—The larger grain borer: *a*, Adult insect; *b*, larva; *c*, pupa; *d*, antenna of adult. Adult borer is shiny polished dark brown, about one-sixth of an inch long. *a*, *b*, *c*, About six times natural size; *d*, highly magnified. (Chittenden.)

LARGER GRAIN BORER.[7]

The larger grain borer is a small, dark brown, elongate-cylindrical beetle about one-sixth of an inch long. As may be seen in figure 13, it is very similar in appearance to the lesser grain borer, but may be distinguished by its larger size and comparatively smooth, polished surface.

This beetle is a tropical insect not as yet widely distributed in this country. It is occasionally found infesting corn (fig. 14) in the Southern States. Its habits are similar to those of the lesser grain borer. It, also, has probably acquired its grain-feeding habits rather recently.

FIG. 14.—Kernel of corn showing work of adult of larger grain borer. The adult borers tunnel in all directions and reduce kernels to powder and shells. Enlarged. (Chittenden.)

GRAIN MOTHS.

The grain moths include only those moths capable of destroying sound, unbroken grain kernels. They are not so abundant as the flour moths, which are principally pests in broken, damaged kernels or milled products.

ANGOUMOIS GRAIN MOTH.[8]

The Angoumois grain moth is a small buff or yellowish brown moth with a wing expanse of about one-half inch. This is the moth most commonly found in infested grain in this country and is not likely to be confused with any other. It attacks all cereal grains, is found in all parts of the world, and is particularly injurious in the South, where it attacks grain both in the field and in storage.

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[7] *Dinoderus truncatus* Horn. [8] *Sitotroga cerealella* Oliv.

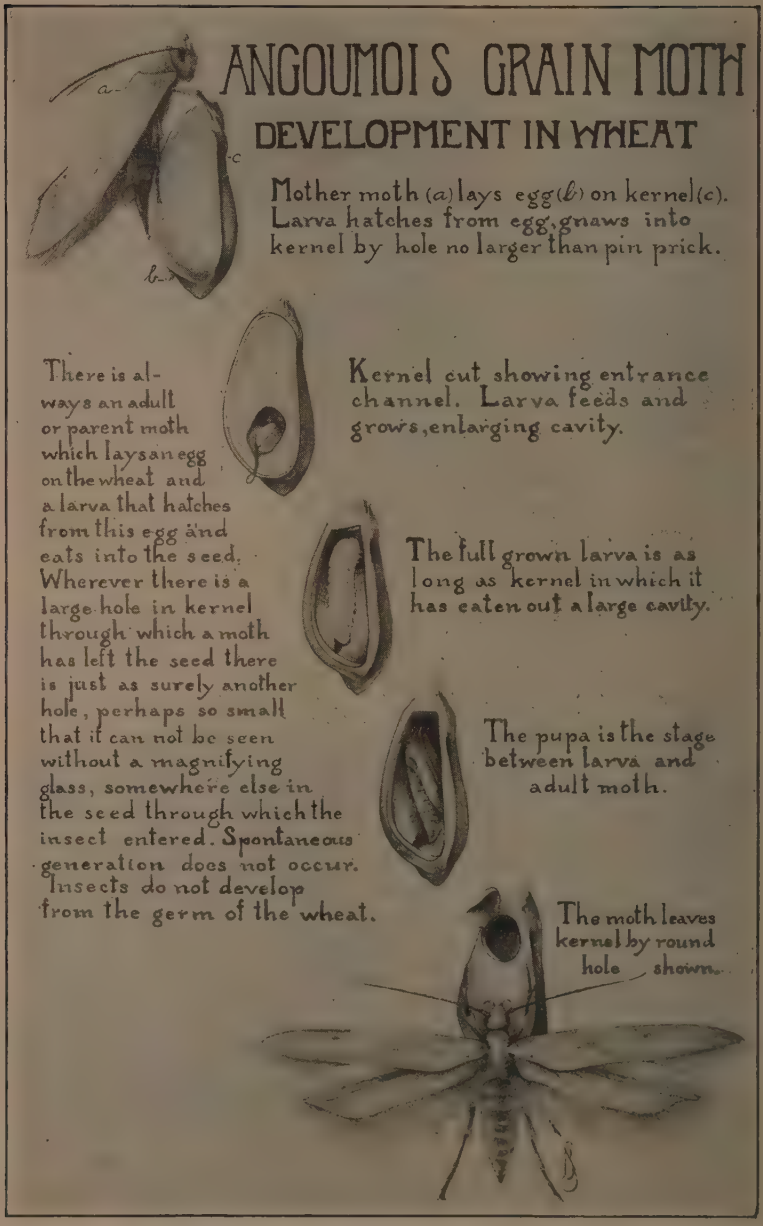
ANGOUMOIS GRAIN MOTH
DEVELOPMENT IN WHEAT
Mother moth (a) lays egg (b) on kernel (c). Larva hatches from egg, gnaws into kernel by hole no larger than pin prick.
a
b
c
There is always an adult or parent moth which lays an egg on the wheat and a larva that hatches from this egg and eats into the seed. Wherever there is a large hole in kernel through which a moth has left the seed there is just as surely another hole, perhaps so small that it can not be seen without a magnifying glass, somewhere else in the seed through which the insect entered. Spontaneous generation does not occur. Insects do not develop from the germ of the wheat.
Kernel cut showing entrance channel. Larva feeds and grows, enlarging cavity.
The full grown larva is as long as kernel in which it has eaten out a large cavity.
The pupa is the stage between larva and adult moth.
The moth leaves kernel by round hole shown.

FIG. 15.—Life cycle of Angoumois grain moth on wheat. (Back.)

Each female moth may lay as many as 150 eggs, which are white when first laid but soon change to a reddish color. The eggs are laid on or near the grain. Upon hatching, the minute white larva or caterpillar bores into a kernel of grain and begins feeding on the contents. When full grown it eats out a channel to the outside of the seed but leaves a thin layer of the seed coat intact. It then changes to a reddish brown pupa, and later the adult or moth emerges, pushing aside the thin section of seed coat that covers the exit from the channel. The development from egg to adult may be completed in five weeks. Figures 15 and 16 show the successive stages in the development of

FIG. 16.—Cross section of ear of corn showing development of Angoumois grain moth in corn. The newly hatched larva crawls down to the germ end of the corn and begins feeding upon the soft germ. As it grows older and stronger it eats out into the firmer portion of the kernel and finally, in most instances, eats to the outer end. (Back.)

this insect in a kernel of wheat and of corn from the time the egg is laid until the adult appears. In figure 17 is shown an ear of corn with the external evidence of heavy attack, and in figure 18 are shown wheat kernels with the emergence holes of the moth. For a further discussion of this pest see Farmers' Bulletin 1156, "The Angoumois Grain Moth."

WOLF MOTH.[9]

The wolf moth is a small moth about the size of the Angoumois grain moth, creamy white and thickly mottled with brown. The mottled appearance distinguishes it from the Angoumois grain moth. It infests all kinds of grain, both in the field and in storage. The larva feeds on the grain and webs the kernels together.

[9] *Tinea granella* L.

Fig. 17.—Ear of popcorn showing heavy infestation by the Angoumois grain moth. Note that certain of the kernels have three emergence holes, and that many have served as food for two moths. The development of a single insect in a kernel causes a loss of from 13 to 24 per cent in weight.

The wolf moth is distributed throughout the Northern States but is not very abundant and can not be compared with the Angoumois grain moth for destructiveness.

PINK CORNWORM.[10]

The pink cornworm is the larva or caterpillar of a small moth (fig. 19). It is about five-sixteenths of an inch long when full grown; pink in color, with head and thoracic shield pale brown. Figure 20 gives a good idea of its appearance. The moth which develops from this worm or larva is smaller than the Angoumois grain moth, with a wing expanse of slightly less than half an inch. The forewings are banded and mottled with yellow, reddish brown, and black, as shown by figure 19. The pale grayish hindwings are very slender and are edged with long fringes. The pupa is shown in figure 21.

This insect is common in the South, where it causes considerable injury to

[10] *Pyroderces rileyi* Wals.

corn, both in the field and in storage. Infestation begins in the field and is continued after the corn is placed in storage. The very characteristic injury is shown in figures 22 and 23. The large amount of frass that is loosely webbed together and fills the interstices between the kernels or is crowded into the cavities of kernels that have been eaten out is a reliable indication of the presence of this pest. The pearly white eggs are laid singly or occasionally in twos or threes. The pinkish larvæ feed on the seed, husk, and cob with equal relish. Though capable of serious injury to corn, in particular as it comes

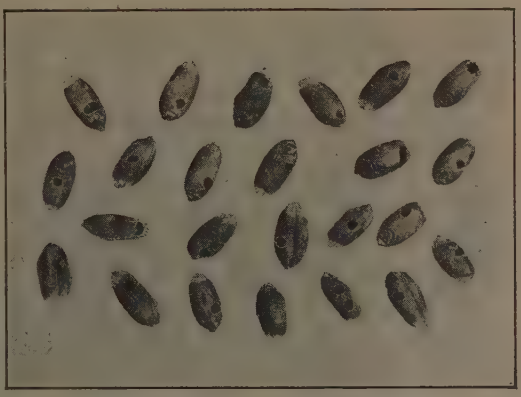

FIG. 18.—Kernels of wheat showing the small round emergence holes that prove that the Angoumois grain moth has developed in the seed, thus reducing the weight somewhat over 50 per cent. (Back.)

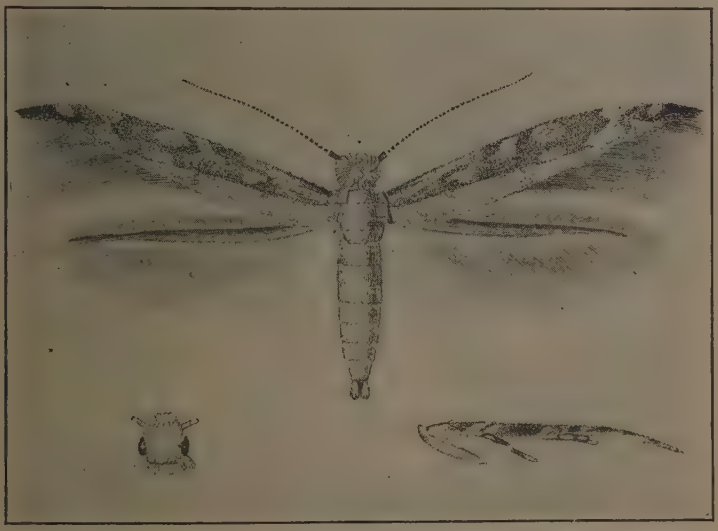

FIG. 19.—The pink cornworm: Moth, much enlarged; head and leg more enlarged. The moth has a wing spread of a little less than half an inch. (Chittenden.)

to maturity in the field, and while in the cribs on Southern farms, the pink cornworm is seldom a serious pest of commercial shipments.

RICE MOTH.[11]

The rice moth has a wing expanse of about half an inch and is of a pale grayish brown or tawny color. Its characteristic appearance is shown in figure 24. The larva (fig. 25) resembles somewhat that of the Indian meal moth, being when full grown about half an inch

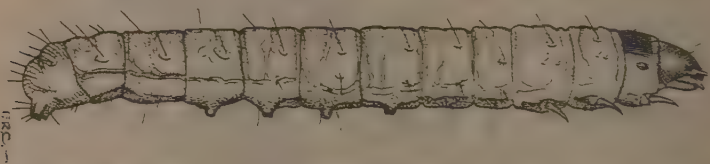

FIG. 20.—The pink cornworm: Full-grown larva, side view, greatly enlarged. When full grown the larva is pink and about five-sixteenths of an inch long. (Chittenden.)

long and varying in color from white to a dirty, slightly bluish gray with occasional tints of green. Damage by the pest, as in the case of all moth pests, is done by the larvæ, which feed upon rice, cocoa, chocolate, ships biscuits, etc. The larvæ produce a dense webbing as they become well grown. When feeding upon grains they spin dense silken tubes, webbing the grain kernels into the walls of the tubes. The pupa is shown in figure 26. The rice moth is seldom found in this country and has not become very widely disseminated.

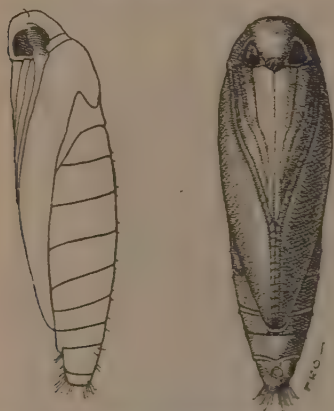

FIG. 21.—The pink cornworm: Pupa, ventral view at right, lateral view at left. Enlarged. (Chittenden.)

FLOUR MOTHS.

Among the flour moths are some of the commonest and most serious pests of grain products. They are designated as flour moths not because they feed entirely upon flour or milled products, but because they seldom attack sound grain kernels. They prefer broken grains, grains injured by major grain pests, and more especially cereal milled products such as flour, breakfast foods, meals, etc. All three of the flour moths are commonly found in grain warehouses, but the Indian meal moth and the meal-snout moth are probably the most frequently reported. These two moths may, under specially favorable conditions, become established in whole grain and other seeds and cause injury especially by eating out the germ.

[11] *Corcyra cephalonica* Staint.

INDIAN MEAL MOTH.[12]

The Indian meal moth is a rather handsome moth with a wing expanse of nearly three-fourths of an inch. It is easily distinguished from other grain pests by the peculiar marking of its forewings. These are reddish brown with a coppery luster on the outer two-thirds, but whitish-gray on the inner or body end. Moths and larvæ are shown in figure 27. The female moths lay from 300 to 400 eggs,

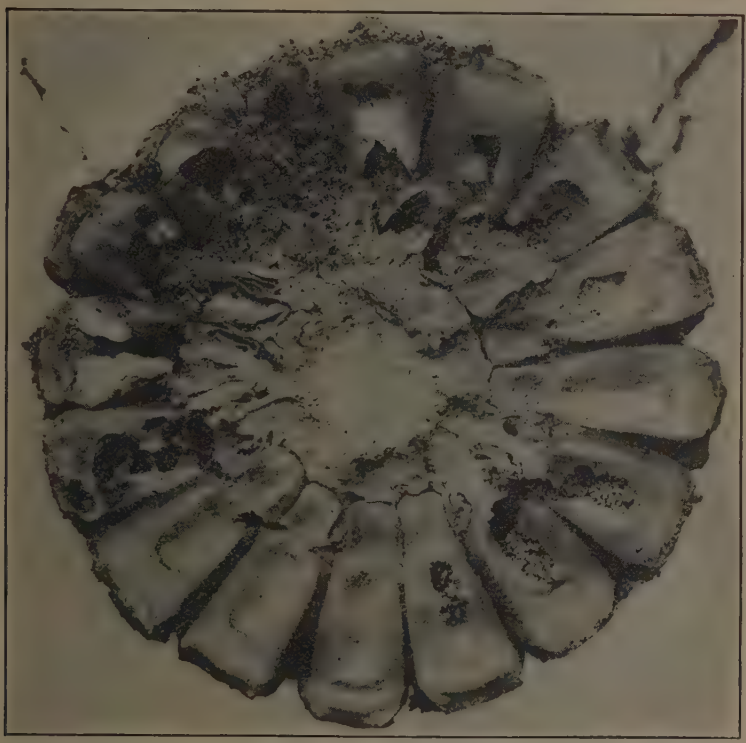

FIG. 22.—Ear of corn cut to show characteristic feeding and destruction by pink corn-worm larvæ. Note that the larvæ eat from one kernel to another, often severing the kernels from the cob. The larvæ sometimes eat into the cob and there transform to the pupa stage. The pupæ are about one-third as long as the kernels shown.

singly or in groups, on food material. The eggs hatch within a few days into small whitish larvæ or caterpillars. These larvæ feed upon grains, grain products, dried fruits, nuts, and a rather wide variety of foodstuffs. When full grown, the larvæ are about half an inch long, dirty white in color, varying sometimes to greenish and pinkish hues. A full-grown larva is shown in figure 28, clinging to a kernel

[12] *Plodia interpunctella* Hbn.

FIG. 28.—Ear of corn with portion of shuck removed to show surface feeding by larvæ of the pink cornworm. Often many kernels drop from the ear when the shucks are removed because of the feeding of the pink cornworm larvæ.

of wheat. This larva spins a silken cocoon and transforms to a light-brown pupa from which the parent moth later emerges. The Indian meal moth may pass through its egg, larva, and pupa stages in about four weeks—during warm weather.

The larva of the Indian meal moth spins a web as it becomes full-grown, and leaves behind a silken thread wherever it crawls. When sacks of cracked corn, meal, or corn in the ear that has been previously injured by other pests become heavily infested, this webbing often is sufficiently abundant to attract attention. The loosely clinging web shown on the ear of corn in figure 29 is characteristic of this pest.

MEDITERRANEAN FLOUR MOTH.[13]

The Mediterranean flour moth has a wing spread of slightly less than one inch. Its hind-wings are a dirty white, but its forewings, which alone show when the moth is not flying, are a pale leaden gray with transverse wavy black markings. (See fig. 30.)

[13] *Ephestia kuehniella* Zell.

The Mediterranean flour moth is a native of Europe. Its first discovery in the United States was in California in 1892. Since then it has spread to practically all the States of the Union and is recognized as the most serious pest of flour mills, owing to the silken threads

FIG. 24.—The rice moth: *a*, Mature moth, dorsal view, with wings spread; *b*, side view of same moth with wings folded about body. The moth is of a grayish brown or tawny color, with a wing spread of about half an inch. Much enlarged. (Chittenden.)

which the larvæ spin wherever they crawl. These webs mat the flour or meal together and eventually clog machinery so that mills have to shut down for a thorough cleaning and treatment. Although preferring flour and meal, the Mediterranean flour moth attacks grain, bran, and cereal products and is commonly found in storehouses and granaries.

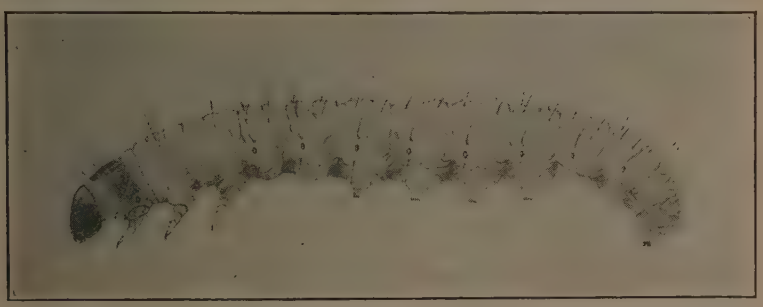

FIG. 25.—Full-grown larva of the rice moth. The full-grown larva is about one-half inch long, and is of a whitish or bluish gray color. Much enlarged. (Chittenden.)

The female moth lays small white eggs in accumulations of flour, meal, or waste grain. From the eggs the small larvæ hatch in a few days. When full grown, these are about half an inch long and are of a whitish or pinkish color with a few small black spots on the body.

The full-grown larva spins a silken cocoon in which the insect transforms to a reddish-brown pupa. Later the parent moth emerges from the pupa. During warm weather, the Mediterranean flour moth requires about nine weeks to pass through its egg, larva, and pupa stages. A more complete discussion of this pest will be found in Bulletin 872 of the United States Department of Agriculture, "Insect Control in Flour Mills."

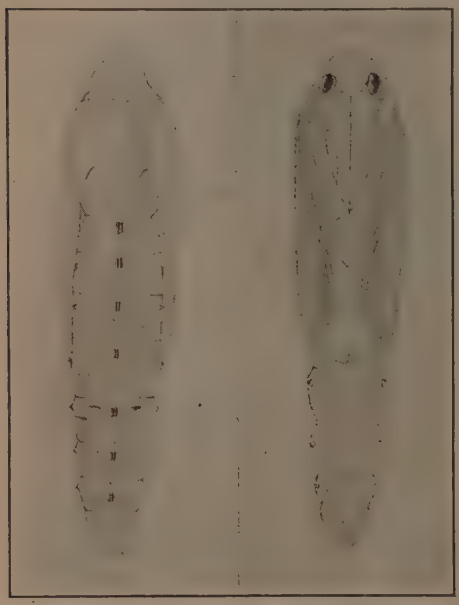

FIG. 26. Pupa of the rice moth: At left, dorsal view; at right, ventral view. The pupa is found in a dense tough cocoon into the walls of which have been spun particles of the food. The cocoons of the Indian meal moth, on the other hand, are very loosely constructed. Much enlarged. (Chittenden.)

MEAL SNOUT MOTH.[14]

The meal snout moth is brownish in color, somewhat larger than the Indian meal moth, though varying in size, usually having a wing spread of about one inch. Its forewings are marked in a characteristic pattern indicated in figures 31 and 32; they are light brown with dark brown patches at base and tip and each with two wavy transverse white lines. The meal snout moth is widely distributed and a general feeder in the larva stage upon cereals of all kinds both ground and in the berry. It sometimes attracts much attention because of its capacity to web up and bind together seeds of various kinds. The larvæ are whitish and attain a length when full grown of about one inch. The two larger larvæ of figure 31 indicate the normal shape and show the contrast between the black of the head and the first body segment and the white of the remainder of the body. Often the body of the larva is tinged with orange toward each end. The larvæ spin peculiar tubes of silk and particles of the food material. They rest in these tubes, which are very tough, and feed from the openings at the ends. When full grown the larvæ leave the tubes, spin silken cocoons, often covered with food particles, and transform to the pupæ from which later emerge the adult moths.

[14] *Pyralis farinalis* L.

The meal snout moth may require only eight weeks to pass through the egg, larva, and pupa stages.

FIG. 27.—The Indian meal moth: Tip of ear of corn showing, *a*, three moths with their characteristic light and dark markings, and *b*, two well-grown larvæ. The adult moth is distinguished from all other grain-infesting moths by having the outer two-thirds of its wings brownish and the inner third whitish gray. It has a wing spread of about three-fourths of an inch.

The meal snout moth is primarily a pest of seeds that are held for some time in cool and damp localities. Outbreaks that have come to the attention of the authors have always been centered in

grain that was harvested during rainy weather or so stored that the moisture content was unusually high. Attempts to rear the moth in dry, warm laboratories have failed. The larvæ cut through burlap sacking and can damage sacks greatly when heavy infestations develop in sacked material. Figure 33 shows the characteristic webbing together of infested seeds—in this instance navy beans—and figure 32 shows the tendency for larvæ to spin their whitish silken cocoons on the outside of grain sacks where the sacks touch each other.

FIG. 28.—Well-grown larva of the Indian meal moth, crawling on kernel of wheat. These worms are white or greenish in color and frequently eat out the germ end of wheat. They attain a length of about half an inch.

MEALWORMS.

There are two species of mealworms in the United States. The adults are the largest of the beetles found in grain and their larvæ are conspicuous, for they attain a length of about one inch and are as large around as an earthworm.

YELLOW MEALWORM.[15]

The adult of the yellow mealworm is a polished dark-brown or black beetle, somewhat more than half an inch long, with its thorax finely punctured and with its wing covers longitudinally striated or grooved. (See fig. 34, at right.) The females lay bean-shaped white eggs covered with a sticky secretion that causes the flour, meal, or grain waste in which they are placed to adhere to them. The eggs hatch in about two weeks into slender white larvæ, which soon turn yellow and assume the form shown in figure 34. When full grown, the larvæ are about an inch long and yellowish, shading to yellowish-brown toward each end and at the articulation of each segment. The pupa into which the larva transforms before becoming an adult beetle is shown in figure 34.

The yellow mealworm is widespread over the world and is frequently found in stored grains. It belongs to a family of beetles[16] known as the darkling beetles because of their preference for dark places. The adults fly only at night. During daylight they conceal themselves, with the larvæ, beneath sacks of grain, under grain boxes,

[15] *Tenebrio molitor* L.

[16] Tenebrionidae.

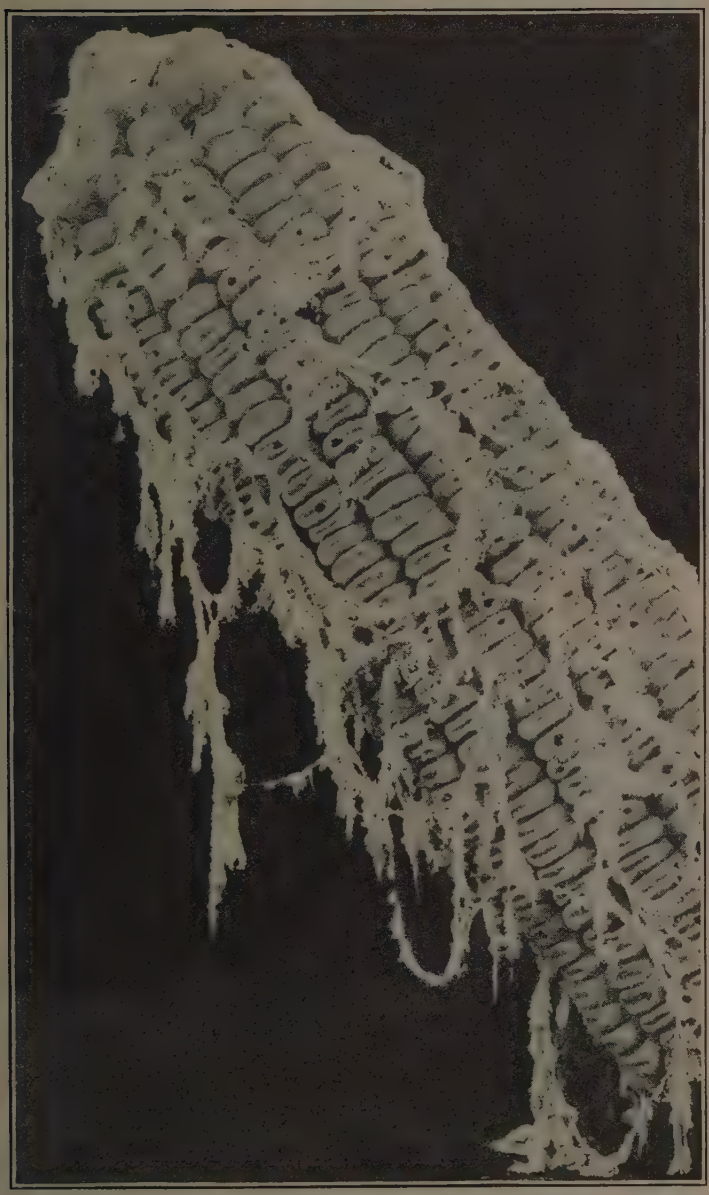

FIG. 29.—Ear of corn showing the loose webbing characteristic of the Indian meal moth larvæ. This moth rarely attacks sound grain, but, as is here shown, frequently attacks grains already injured by other grain pests. Such webbing as is here shown develops only when corn or other grains are left unmoved for some time.

or beneath grain and other food. There is but one generation each year. The adults begin to appear in the latitude of Washington during May and by June have laid most of their eggs and have died.

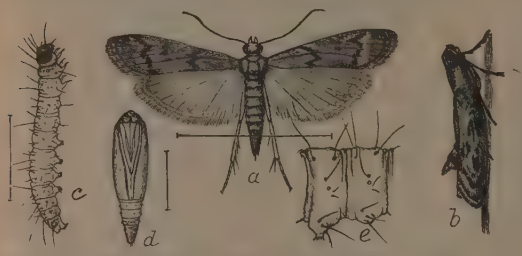

FIG. 30.—The Mediterranean flour moth: *a*, Moth; *b*, same from side, resting; *c*, larva; *d*, pupa (enlarged); *e*, abdominal joint of larva (more enlarged). The adult moth, with a wing expanse of a trifle less than one inch, is leaden gray in color, marked with transverse wavy black markings. The full-grown larva is whitish or pinkish in color, with small black spots, and is about one-half an inch long. (Chittenden.)

Farther north the adults appear during June. The larvæ become full grown in about three months, but instead of transforming then to the adult stage they continue feeding and molting until cold weather and then hibernate as larvæ. The following spring they transform to the pupa stage, in which the insect passes about two weeks. Because the yellow mealworm has but one generation each year, and is entirely an external feeder upon grains, it need not be feared as a serious pest. Screening and fanning

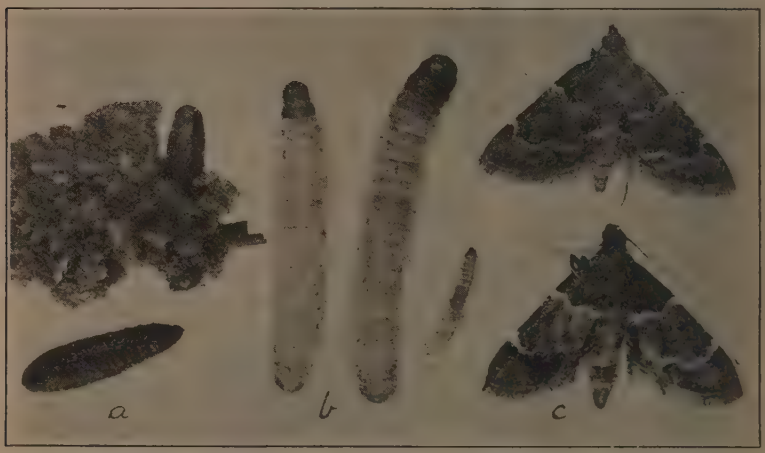

FIG. 31.—The meal snout moth: *a*, Pupa and, above, webbed mass of grain showing portion of pupa protruding; *b*, two well-grown larvæ with a smaller larva at right; *c*, two adult moths. Magnified about one and one-half times. The markings on the forewings easily distinguish this insect from other grain pests.

will remove it easily from grain shipments. The well-grown larvæ, however, can do serious injury to whole grains under certain conditions when grain is held for long periods without being moved.

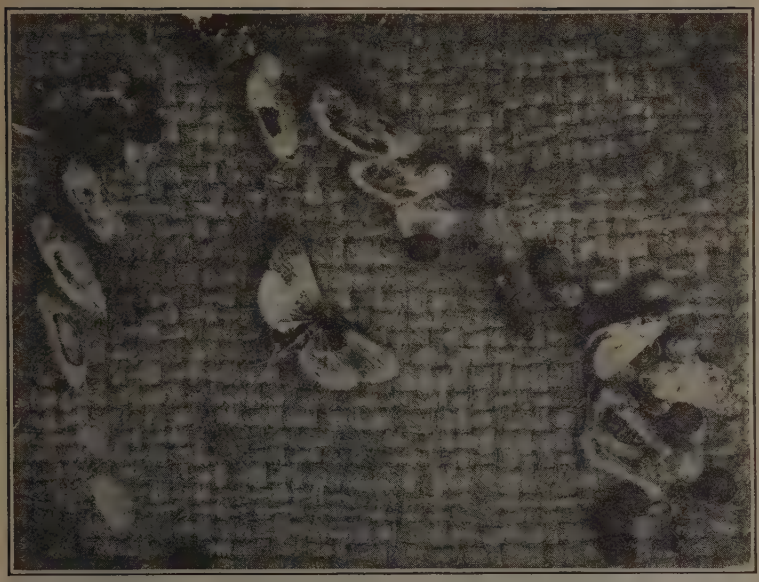

FIG. 32.—Inside of a grain sack that was filled with infested vetch seed. Note vetch seeds sticking to side of bag as a result of the webs of the larvæ of the meal snout moth, the numerous whitish cocoons with dark pupæ within, and, in the center, one adult moth. Natural size.

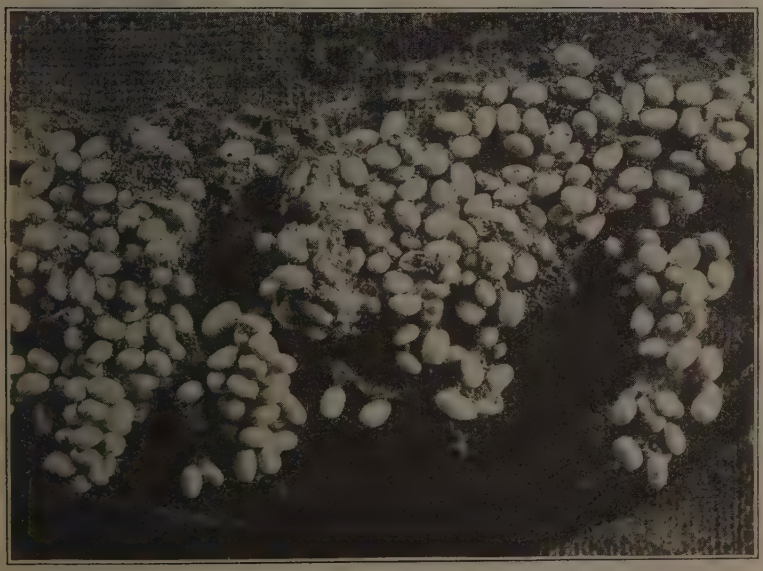

FIG. 33.—Navy beans webbed together by larvæ of the meal snout moth, and adhering to sack. The larvæ often cut sacks so seeds fall out and lodge where sacks touch each other. In these places the seeds are usually more heavily infested.

DARK MEALWORM.[17]

The dark mealworm, as may be seen by the larva, pupa, and adult shown in figure 35, is very similar in form, size, and color to the yellow mealworm, to which it is closely related. The adult beetle differs, however, in being dull pitchy black, in contrast to the shiny or polished dark brown or black of the yellow mealworm. Its larva so closely resembles the larva of the yellow mealworm that it can be distinguished most easily by its much darker color. The two

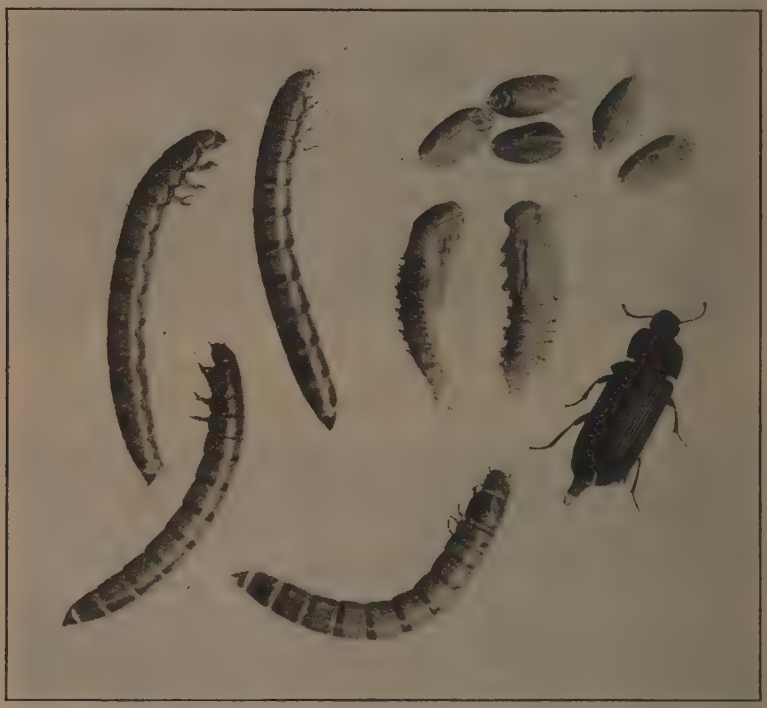

FIG. 34.—The yellow mealworm. Four well-grown larvæ, two pupæ, and the black adult beetle, with five kernels of wheat to indicate relative size. The larvæ when full grown are about one inch long and yellowish. The adult beetles are shiny black and slightly more than half an inch long.

species of mealworm are often found associated, and what has been said of the stages of the yellow mealworm applies equally well to the dark mealworm.

GRAIN AND FLOUR BEETLES.

CADELLE.[18]

The cadelle is an elongate, oblong, flattened, black or blackish beetle about one-third of an inch long. It resembles the mealworms

[17] *Tenebrio obscurus* Fab.

[18] *Tenebroides mauritanicus* L.

in appearance, but is much smaller and the thorax and abdomen are loosely joined. (See fig. 36.)

The larva of the cadelle is one of the largest of the grain-infesting insects and is easily recognized. It is about three-quarters of an inch long, fleshy, with the abdomen terminating in two dark horny points. The larva is a dirty or chalk white, with head, thoracic shield, and the two horny points at end of body black, as shown in figure 37.

This insect is widespread over the world and is frequently found in mills, granaries, and storehouses, where it infests flour, meal, grain, etc. Both larva and adult feed on grain and have the destructive habit of going from kernel to kernel and devouring the embryo.

FIG. 35.—The dark mealworm: *a*, Full-grown larva; *b*, pupa; *c*, adult beetle. Distinguished from the yellow mealworm by the dark brown color of the larva and the dull, not shiny appearance of the adult beetle. For true relative size of the larva, pupa, and adult compare with figure 34.

The cadelle often becomes well established in ear corn (fig. 38) that has first been injured by the Angoumois grain moth or by the weevils. The long slits in corn kernels shown in figure 38 are characteristic of cadelle infestation. Were it not for the fact that there is not more than one generation of this insect each year the cadelle would be one of the most serious enemies of stored grain. As it is it is probably the longest lived of the insects that attack stored grain, and frequently causes severe losses.

The white eggs are laid in clusters in the food material selected and hatch in about 10 days. When the larvæ become fully grown they seek some secluded place in which to transform to the pupa (fig. 39), frequently boring into the timbers of the bin or other re-

FIG. 36.—The cadelle: Adult beetle. The cadelle is a flattened, black beetle about one-third of an inch long.

ceptacle that holds the infested material. Both larvæ and beetles feed to some extent on other grain-infesting insects, hence are partly predacious.

SAW-TOOTHED GRAIN BEETLE.[19]

The saw-toothed grain beetle gains its name from the peculiar structure of the thorax, which bears six sawtoothlike projections on each side (fig. 40). This character is a ready means of distinguishing this beetle from others that infest stored grain. It is about one-tenth of an inch long, slender, much flattened, and dark chocolate brown in color. A cosmopolitan beetle, extremely abundant at times, it is nearly omnivorous, infesting grains, flours, meals, dried fruits, seeds, etc. Both beetle and larva are very active.

The small slender eggs hatch in a few days. The emerging larvæ do not spend their lives within a single grain but crawl about actively, feeding here and there. When full grown (fig. 40), they are whitish, with dark markings, somewhat flattened in form, and have three pairs of legs and an abdominal proleg. When ready to pupate they construct delicate cocoon-like coverings by joining together small grains or fragments of foodstuffs with a sticky secretion and within this the pupa (fig. 40) and later the adult form are assumed. Development from egg to adult may take place in 24 days in summer.

FIG. 37.—The cadelle: Larva. Commonly found crawling among grain kernels. It may appear glistening white or dull and powdered according to the material in which it is crawling. When full grown it is about three-fourths of an inch long.

SQUARE-NECKED GRAIN BEETLE.[20]

The square-necked grain beetle is closely related to the saw-toothed grain beetle, which it greatly resembles in form, size, and color. It is a flattened, oblong, polished, reddish brown beetle about one-tenth of an inch long. It differs from the saw-toothed grain beetle

[19] *Oryzaephilus surinamensis* L. [20] *Silvanus gemellatus* Duv.

by having the thorax almost square in shape and lacking the sawtoothlike projections. (Fig. 41.)

This beetle is chiefly abundant in the South, where it is found in great numbers outdoors infesting the seed pods of a great variety of plants. It is one of the most common beetles in stored corn in the South and in the cornfields is always to be found on damaged or exposed ears. The immature stages closely resemble those of the preceding species both in form and in habit. The larvæ have the bad habit of devouring the germ of the seed in which they breed. They can develop from egg to adult in about three weeks.

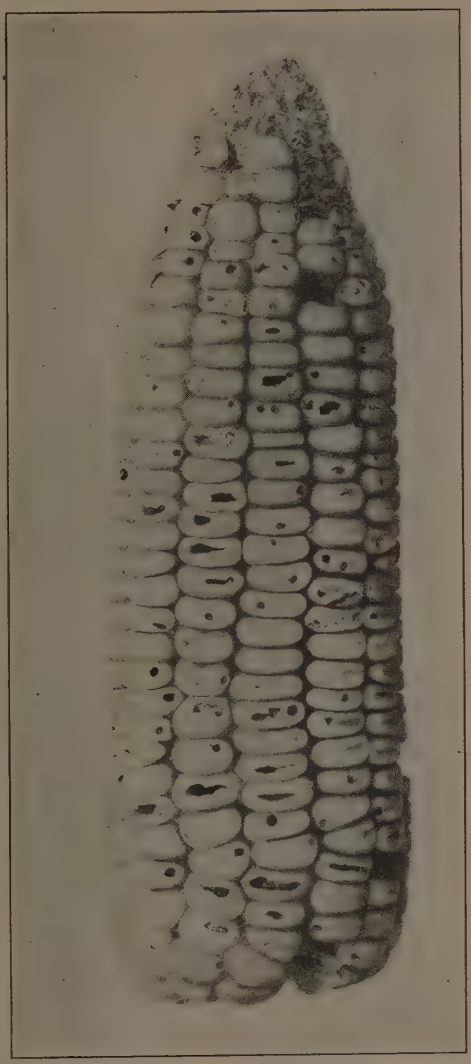

FIG. 38.—Ear of corn infested by the Angoumois grain moth (round holes in kernels) and the cadelle. The elongated slits in the kernels are characteristic of cadelle feeding and emergence. Only ear corn stored for several years will develop this evidence of cadelle attack.

FOREIGN GRAIN BEETLE.[21]

The foreign grain beetle is a small reddish brown beetle somewhat similar in appearance to the preceding species, to which it is closely related. It differs from it by being smaller and more robust. (Fig. 42.) Although of world-wide distribution, it is of little consequence as an enemy of stored grains. It is attracted to damp and moldy grains and feeds on the molds developing in such grains. It is rarely found in clean grain.

[21] *Cathartus advena* Waltl.

FIG. 39.—The cadelle: Pupa, much enlarged. The pupa is seldom seen as this stage of the cadelle's life cycle is spent in a cell made in an inaccessible place.

MEXICAN GRAIN BEETLE.[22]

The Mexican grain beetle is a highly polished, deep brown beetle about three-sixteenths of an inch long. While resembling somewhat the confused flour beetle in general appearance, it can be readily distinguished by its more polished surface and by its longer antennæ. (Fig. 43.)

This insect is common in Mexico, where it breeds in grain and grain products. It was found in this country in grain exhibits at the World's Columbian Exposition, but is not known to be permanently established in this country as yet. It may be found in grain in the extreme South.

SIAMESE GRAIN BEETLE.[23]

The Siamese grain beetle is an elongate, flattened, reddish-brown beetle slightly less than an eighth of an inch long characterized

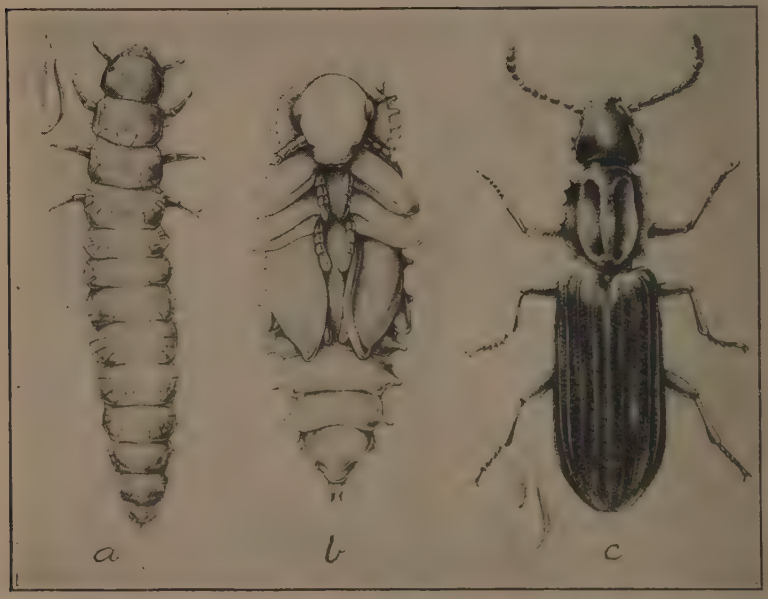

FIG. 40.—The sawtoothed grain beetle: *a*, Well-grown larva, with kernel of wheat to show its relative size; *b*, pupa; *c*, adult beetle with kernel of wheat to show its relative size. The adult beetle, about one-tenth of an inch in length, can be easily recognized by the six toothlike projections on the sides of the thorax.

[22] *Pharaxonotha kirschi* Reitt. [23] *Lophocateres pusillus* Klug.

by the much flattened margins of the thorax and wing covers (fig. 44).

First appearing in exhibits of rice and cereals from Siam, Liberia, and Ceylon at the World's Columbian Exposition, it has since been reported as injurious to stored grain and grain products in South Carolina and Texas. It is likely to be found in seaport towns and in the Southern States, but as yet it is not abundant or widespread.

FIG. 41.—The square-necked grain beetle. (Chittenden.)

FLAT GRAIN BEETLE.[24]

The flat grain beetle is a small, flattened, oblong, reddish-brown beetle about one-sixteenth of an inch long, with elongate antennæ somewhat longer than half the length of its body. (Fig. 45.) It is readily distinguished because it is the smallest beetle commonly found in stored grain in this country. It is cosmopolitan in distribution, is very generally found in stored corn in the South, and is often screened from wheat shipments. Little is known of its habits or of its early stages, though it is thought to be a scavenger or predacious on other insects. The full-grown larvæ form cocoons of a gelatinous substance to which food particles adhere. While it is present sometimes in unbelievable numbers in grain shipments, it appears to do little damage to whole grains. The larvæ have been found destroying the germ in kernels of wheat.

FIG. 42.—The foreign grain beetle. (Chittenden.)

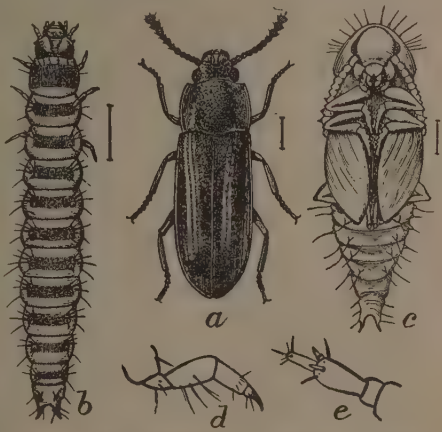

FIG. 43.—The Mexican grain beetle. *a*, Beetle; *b*, larva; *c*, pupa; *d*, leg of larva; *e*, antenna of larva. *a*, *b*, *c*, Much enlarged; *d*, *e*, more enlarged.

[24] *Cryptolestes pusillus* Schon.

CONFUSED FLOUR BEETLE.[25]

The confused flour beetle (fig. 46) is a shiny, reddish-brown beetle about one-sixth of an inch long, flattened and oval in form, with head and upper parts of thorax densely covered with minute punctures and with wing covers ridged lengthwise and sparsely punctured between the ridges. It is generally distributed over the world and is very abundant in all parts of this country. It is known as one of the flour beetles owing to its frequent occurrence in flour. It is a general feeder on starchy foods and is probably the worst insect pest of prepared cereal foods. It is constantly found in granaries, mills, and storehouses, and grain shipments.

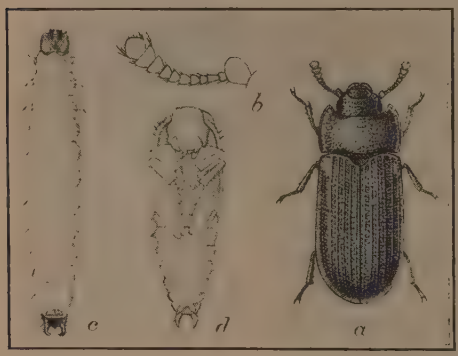

FIG. 44.—The Siamese grain beetle. *a*, Beetle; *b*, antenna of same; *c*, larva; *d*, pupa. *a*, *c*, *d*. About ten times natural size; *b*, greatly enlarged.

The minute white eggs of this beetle are laid in the cracks and crevices of bins, barrels, boxes, or other containers of the foodstuffs attacked by this insect. They are covered with a sticky secretion so that they become covered with flour, meal, etc., and readily adhere to the sides of sacks, boxes, and other containers so that fresh material placed in them is rapidly infested. The eggs hatch into small wormlike larvæ, slender, cylindrical, and wiry in appearance. When fully grown they are about three-sixteenths of an inch long, and in color are white, tinged with yellowish. These larvæ feed on flour or other material such as grain dust and the broken surfaces of grain kernels. When full grown they transform to small naked pupæ. At first white, the pupæ gradually change to yellow and then brown, and shortly afterwards transform to beetles. The period from egg to adult in summer is about four weeks under most favorable weather conditions, though the

FIG. 45. Adult of the flat grain beetle, showing characteristic long antennæ. Not more than one-sixteenth of an inch long. This beetle is one of the very smallest found in grain shipments.

[25] *Tribolium confusum* Duv.

life cycle is greatly prolonged by cold weather, as is true of all grain pests.

RUST-RED FLOUR BEETLE.[26]

The rust-red flour beetle is almost identical in appearance with the preceding species, to which it is closely related. It can be distinguished from the confused flour beetle only with the aid of a magnifying glass. The segments of the antennæ of the confused flour beetle increase in size gradually from the base to the tip, while in the rust-red flour beetle the last few segments of the antennæ are abruptly much larger than the preceding ones, giving the antennæ the appearance of being suddenly enlarged at the tip. In addition, the margins of the head of the confused flour beetle are expanded and notched at the eyes, while the margins of the head of this species are nearly continuous at the eyes. The differences between the two species are clearly shown in figure 46, *e* and *f*.

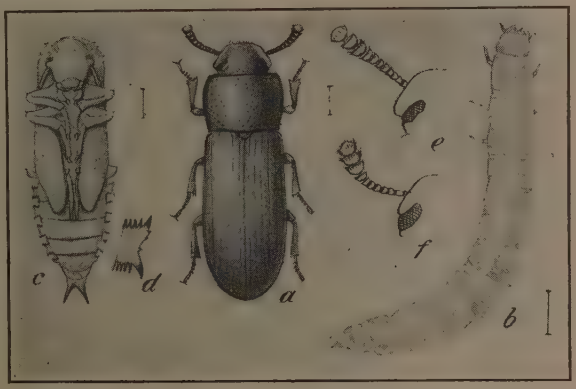

FIG. 46.—The confused flour beetle, the commonest insect recovered from grain shipments. It is about one-sixth of an inch long. *a*, Beetle; *b*, larva; *c*, pupa; *d*, lateral lobe of abdomen of pupa; *e*, head of beetle, showing antenna; *f*, same of the rust-red flour beetle. (Chittenden.)

This insect is similar to the confused flour beetle in feeding and breeding habits, and it is impossible to distinguish between the early stages of the two insects. Although cosmopolitan in distribution, it is found more commonly in the South, where it causes very serious damage to grain products. In addition to the actual damage caused by its feeding activities, serious losses are caused by the nauseous smell and taste that it imparts to the material it infests. Like the confused flour beetle, the rust-red flour beetle is primarily a pest of milled products, and while present in grain shipments it confines its attack in these to grain dust and the surface of broken grains, hence is not a primary pest of commercial shipments.

LONG-HEADED FLOUR BEETLE.[27]

The long-headed flour beetle is a slender, flattened beetle, slightly less than an eighth of an inch long, somewhat similar in form to the

[26] *Tribolium ferrugineum* Fab.

[27] *Latheticus oryzae* Waterh. A closely related species, *Latheticus prosopsis* Chittn., is shown in figure 48.

confused flour beetle but pale yellow and further differentiated by the peculiarly shaped antennæ shown in figure 47 and by the minute canthus behind each eye. It has been reported from most parts of the world infesting wheat, rice, corn, barley, rye, flour, etc. It was first recognized in this country about 13 years ago from specimens taken in Texas. It is not known to be very widely distributed in the United States but is likely to be found in mills and granaries in the South.

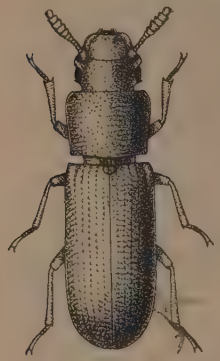

FIG. 47.—Long-headed flour beetle. (Chittenden.)

SLENDER-HORNED FLOUR BEETLE.[28]

The slender-horned flour beetle owes its name to the peculiar structure of the mandibles or jaws of the male, which are armed with a pair of slender incurved horns as shown in figure 49. The beetle is about one-eighth of an inch long, flattened and brownish, closely resembling the other flour beetles in appearance but easily distinguished by the peculiar structure of the jaws. It is distributed over the world and of frequent occurrence in the Southern States. It prefers to feed in flour and meal, but is found in a variety of grains.

BROAD-HORNED FLOUR BEETLE.[29]

The broad-horned flour beetle is closely related to the preceding species and is of similar form and appearance. It may be distinguished from it by the shape of the horns with which the mandibles or jaws of the males are armed. In this species (fig. 50) the horns are broad and stout in contrast to the slender incurved horns of the preceding species. Its habits are similar to those of the slender-horned flour beetle, and it is often found in seaport towns in shipments of grain and grain products.

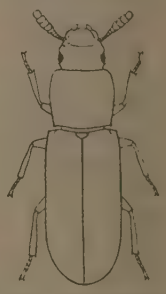

FIG. 48.—*Lathetieus prosopis*. (Chittenden.)

SMALL-EYED FLOUR BEETLE.[30]

The small-eyed flour beetle (fig. 51) is the smallest of the so-called flour beetles that infest grain and grain products in this country. It is a tiny, flattened, shiny, reddish-brown beetle, somewhat oblong in form and measuring about one-twelfth of an inch in length. It occurs throughout the world and is widely distributed in this country. It prefers ground products in which to breed, but is not infrequently found in stored grains.

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[28] *Gnathocerus maxillosus* Fab. [29] *Gnathocerus cornutus* Fab. [30] *Palorus ratzeburgi* Wissm.

A closely related species[31] more common in Europe but occasionally found in this country is very similar in appearance and habits to the small-eyed flour beetle.

TOBACCO BEETLE.[32]

The tobacco beetle is a small, robust, oval, reddish-yellow or brownish red beetle, with head bent down nearly at right angles to the body, giving the beetle a humped appearance when viewed from the side as shown in figure 52. It varies in size, but is usually about one-tenth of an inch long. It is found in all temperate, subtropical, and tropical regions and infests tobacco and many other stored products. It breeds in a variety of seeds and may occasionally be found attacking grains left long in storage in original sacks.

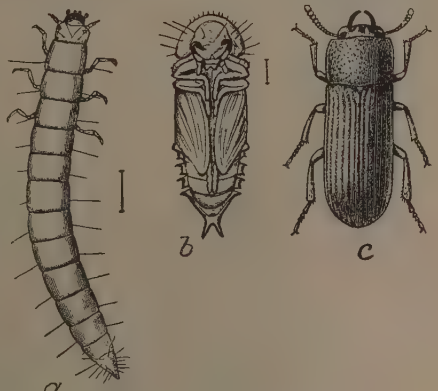

FIG. 49.—The slender-horned flour beetle: *a*, Larva; *b*, pupa; *c*, beetle. (Chittenden.)

DRUG-STORE BEETLE.[32]

The drug-store beetle is very similar in appearance to the tobacco beetle, to which it is closely allied, but differs from it by being more elongate in proportion and in having the wing covers distinctly striated. It is about one-tenth of an inch long. It is cylindrical and uniform light brown; its body is covered with a fine silky pubescence. (See fig. 54.) The larva or grub is very much less hairy than that of the cigarette or tobacco beetle, as a comparison of figures 53 and 55 will show. It is known as the drug-store beetle from its habits of feeding on almost all drugs found in pharmacies. It is a very general feeder, attacking a great variety of stored foods, seeds, and other materials, and has been said to "eat anything except cast iron." It is frequently found in storehouses and granaries in all parts of the world.

FIG. 50.—The broad-horned flour beetle. (Chittenden.)

The eggs of this beetle are laid in almost any dry organic substance. The small white grubs emerging from the eggs tunnel through these substances and when full grown pupate in small cocoons. The entire life cycle may be passed in less than two months.

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[31] *P. depressus* Fab. [32] *Lasioderma serricorne* Fab. [32] *Sitodrepa panicea* L.

FIG. 51.—The small-eyed flour beetle. (Chittenden.)

BLACK CARPET BEETLE.[34]

The black carpet beetle is a small oval beetle between two-sixteenths and three-sixteenths of an inch long. The head and thorax are black, but the wing covers may be either black or dark reddish brown, and clothed with short hairs. Its legs and antennæ are dark yellowish in color. The larva is very characteristic and can be readily recognized. It is reddish or golden brown, clothed with short scale-like appressed hairs and provided with a tuft of long hairs at the end of the body, as shown in figure 56.

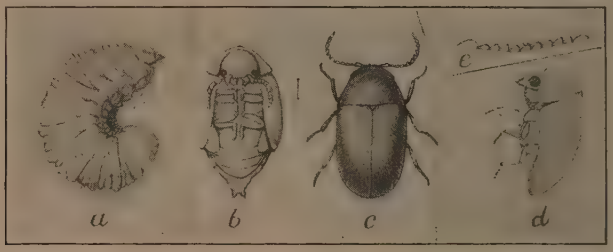

FIG. 52.—The tobacco beetle never attacks grain unless it has been stored for long periods. *a*, Larva; *b*, pupa; *c*, beetle, dorsal view; *d*, beetle, side view; *e*, antenna of beetle. (Chittenden.)

As the name indicates, this insect injures carpets, but in addition it is known to breed in grains and cereals, both whole and ground. The larval stages develop very slowly, and there is but one generation each year. The adults appear in greatest numbers during the spring and early summer. It occurs in Europe and Asia and has been reported from all parts of this country. It is of very common occurrence in houses.

FIG. 53.—The tobacco beetle: Head and leg of larva. (Chittenden.)

LARGER CABINET BEETLE.[35]

The larger cabinet beetle is a small, oval beetle about one-eighth of an inch long, its ground color black mottled with reddish brown, covered with gray and light brown scale-like hairs forming a distinct pattern on the wing covers. The larva somewhat resem-

[34] *Attagenus piceus* Oliv. [35] *Trogoderma tarsale* Melsh.

bles that of the black carpet beetle in appearance. It is about one-eighth of an inch long, reddish brown above and whitish beneath, with body covered with short yellowish brown hairs and with a tuft of short hairs at the tail end. (See fig. 57.) It is well known for its habit of breeding in dead insects and animal substances and is not infrequently found living in grain, flaxseed, castor beans, pumpkin seed, etc. It often becomes a nuisance in laboratories by attacking sample lots of corn, wheat, etc.

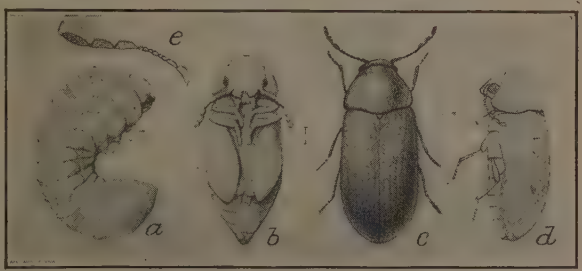

FIG. 54.—The drug-store beetle never attacks grain unless it is stored for long periods unmolested. *a*, Larva; *b*, pupa; *c*, beetle, dorsal view; *d*, beetle, side view; *e*, antenna of beetle. (Chittenden.)

SMALL CABINET BEETLE.[36]

The small cabinet beetle is somewhat similar in appearance to the larger cabinet beetle but smaller and of different color. It varies in length from one-sixteenth to two-sixteenths of an inch, and is black with yellowish white scales that form a broad band across the back and give the body a mottled appearance. The habits of the adult and early stages of this insect are similar to those of the larger cabinet beetle. It is occasionally found in flour mills and granaries, where it infests grain and grain products.

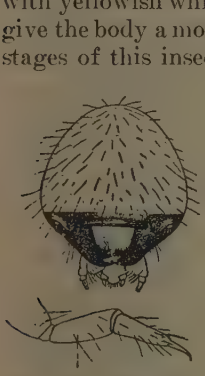

FIG. 55.—The drug-store beetle: Head and leg of larva. (Chittenden.)

MUSEUM BEETLE.[37]

The museum beetle is closely allied to the preceding beetle and resembles it in size and form. Its body is black, covered with yellowish and whitish scales, giving it a spotted appearance. It is a small plump beetle varying in size from one-sixteenth to one-eighth of an inch in length. The larvæ are small active hairy grubs with habits similar to those of the two preceding species. They are occasionally found in grains, both whole and ground, but do not cause noticeable damage.

TWO-BANDED FUNGUS BEETLE.[38]

The two-banded fungus beetle is a handsome little elongate-oval beetle slightly less than an eighth of an inch long. It is red-brown with two broad black bands across the wing covers. Its character-

[36] *Anthrenus verbasci* L. [37] *Anthrenus museorum* L. [38] *Alphitophagus bifasciatus* Say.

istic color pattern is shown in fig. 58. It is distributed over the world and is in general a feeder on fungi and molds, being a scavenger in refuse grain and grain products, decaying vegetable matter, etc. It is frequently found around mills and storehouses where waste material is allowed to accumulate. The larvæ have been bred from moist cornmeal and in spoiled cereals. The insect is often found in the holds of grain ships in wet or damaged grain.

BLACK FUNGUS BEETLE.[39]

The black fungus beetle (fig. 59) resembles the mealworm beetles in form and color but is considerably smaller. It is black or a very dark reddish brown and measures from three-sixteenths to four-sixteenths of an inch in length. The larva (fig. 59, *a*) is yellowish

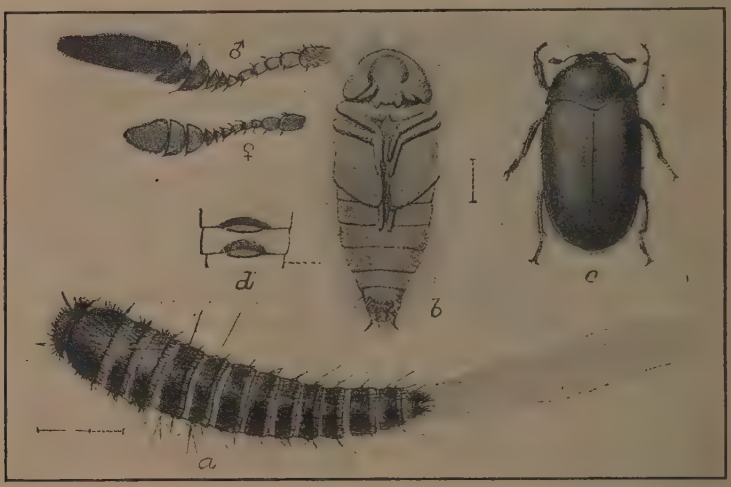

FIG. 56.—The black carpet beetle is chiefly a pest of sample grains, or found in grain dust about elevators or storage bins. *a*, Larva; *b*, pupa; *c*, beetle; *d*, dorsal abdominal segments of pupa; ♂, antenna of male beetle; ♀, antenna of female beetle. (Howard.)

brown and is very similar in form and appearance to young larvæ of the mealworms. This beetle is often found in the same situations as the red-banded fungus beetle. It breeds in damp moldy grain but causes no injury to grain that is sound and dry.

CORN SAP-BEETLE.[40]

The corn sap-beetle may be readily recognized by its peculiar wing covers, which are short and truncate, leaving the tip of the abdomen exposed as shown in figure 60. It is a small dark brown beetle with lighter colored wing covers, oblong-ovoid in shape, and varying in length from one-tenth to one-eighth of an inch. It normally feeds in

[39] *Alphitobius piceus* Oliv. [40] *Carpophilus dimidiatus* Fab.

rotting and decaying fruit and vegetation and in the sap exuding from injured plants. It is quite numerous in cornfields in the South, swarming over the damaged ears and feeding and breeding in the decaying kernels. It is attracted to damp and decaying grain but is seldom found in grain that is clean and dry.[41]

FIG. 57.—The larger cabinet beetle: At left, pupa within larval skin; in center, pupa; at right, beetle; below, well-grown larva.

A closely related beetle[42] that has been introduced from abroad and is becoming more and more abundant is similar in form to the corn sap-beetle, but is slightly larger and is a uniform, shiny, dark brown all over. Its habits are very similar to those of the preceding species.

BOOK-LICE OR PSOCIDS.[43]

Book-lice or psocids are minute, pale, soft-bodied, louse-like insects, about one thirty-second of an inch long, with long, slender antennæ, differing greatly in appearance from other grain-infesting insects. (See fig. 61.) They may be whitish, almost transparent, or quite dark.

FIG. 58.—The two-banded fungus beetle. Adult.

Psocids are of very common occurrence and may be found in nearly any situation. They are almost omnivorous, feeding on any animal or vegetable matter. They are frequently found in grain, but while they have jaws and are capable of feeding upon solid materials, they may be disregarded as pests of grain. They are frequently very abundant in grain and are here recorded because of the curiosity of persons to know what they are. For further information regarding them see Farmers' Bulletin 1104, "Book-Lice or Psocids."

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[41] *Carpophilus pallipennis* Say, a purely flower-infesting beetle, has been occasionally reported as infesting stored corn. In these cases large specimens of the corn sap-beetle which closely resemble this species were probably mistaken for it.

[42] *Carpophilus humeralis* Murray.

[43] *Troctes divinatoria* Fab. *et al.*

MITES.[44]

Mites are pale-colored, soft-bodied creatures provided with numerous long hairs, as illustrated in figure 62. They are microscopic in size. As a low estimate the number of mites that may be found on one square inch has been placed at 100,000. They are often found in stored grain and occasionally increase with such rapidity that the grain seems to be fairly alive with them. During heavy infestations their cast skins and dead bodies accumulate in fluffy light brown masses beneath the sacks of grain. If these accumulations are on a warehouse floor they roll up into piles which are blown about with each gust of wind. No other group of pests in

FIG. 59.—The black fungus beetle: *a*, Larva; *b*, pupa; *c*, adult; *d*, caudal segment of larva (Schiödte); *e*, lateral plate of pupa (Schiödte).

grain will produce these masses. When present in large numbers they promote "sweating," impart a disagreeable odor to the grain, and may cause damage by their feeding. Fortunately the mites that attack grain are themselves preyed upon by predacious mites which usually become abundant enough to kill the grain mites in a comparatively short time. If they do not, the screening and fanning of grain will usually reduce mite infestations to a point where no injury takes place.

PARASITES OF GRAIN PESTS.

Grain in bulk is often seen swarming with small black wasplike insects of a size and appearance shown in figure 63. These do

[44] *Tyroglyphus* spp.

not cause injury to grain. On the contrary, they are beneficial, as they are attacking and killing the grain weevils and grain moths. While parasites kill a large number of grain insects, they unfortunately can not be considered of great importance from the standpoint of grain protection, for by the time the grain insects have been controlled by parasites the grain itself has become very badly damaged. For this reason the appearance of a large number of parasites in grain cars or elevators should be disregarded and the grain treated as though parasites were not present.

FIG. 60.—The corn sap-beetle. Adult.

Grain dealers frequently find a small threadlike white worm[45] (fig. 64) about three-quarters of an inch long in grain dust beneath sacks or in the bottoms of bins. This is the larva of a small black fly to be found crawling upon windows of granaries and flour mills. Because of this habit it is called the window-pane fly. Its threadlike larva does no harm to grain but is predacious upon the larvæ of grain pests and clothes moths. It is not abundant enough to be of value in protecting grain.

FIG. 61.—Book-louse or psocid.

HOW GRAIN BECOMES INFESTED.

Grain may become infested in a number of ways. It is never possible to settle satisfactorily litigation over responsibility for insect damage to grain without a thorough knowledge of the history of the particular grain shipment involved.

Several of the worst insect pests of grain, notably the Angoumois grain moth and the rice or black weevil, fly to the grain fields from near-by cribs and begin their attack upon the maturing grain. In the case of wheat and similar small grains, the eggs of the insect are laid directly upon the heads of grain. In the case of corn the insects can infest only those kernels that are exposed because of poorly de-

[45] *Scenopinus fenestralis* L.

veloped or damaged shuck covering. In cornfields, especially in the South, where insect infestation occurring in the field is most severe, there are a sufficiently large number of exposed kernels to bring about slight, though widespread, infestation.

It is probably true that in well-grown crops of corn the percentage of kernels infested before the crop is ready for harvest is very small, and throughout the Middle and Northern States is a negligible factor. In the Gulf Coast States, especially in upland fields, the infestation often is very severe. In the case of wheat, grown particularly along the Ohio River, in southern New Jersey, in Pennsylvania,

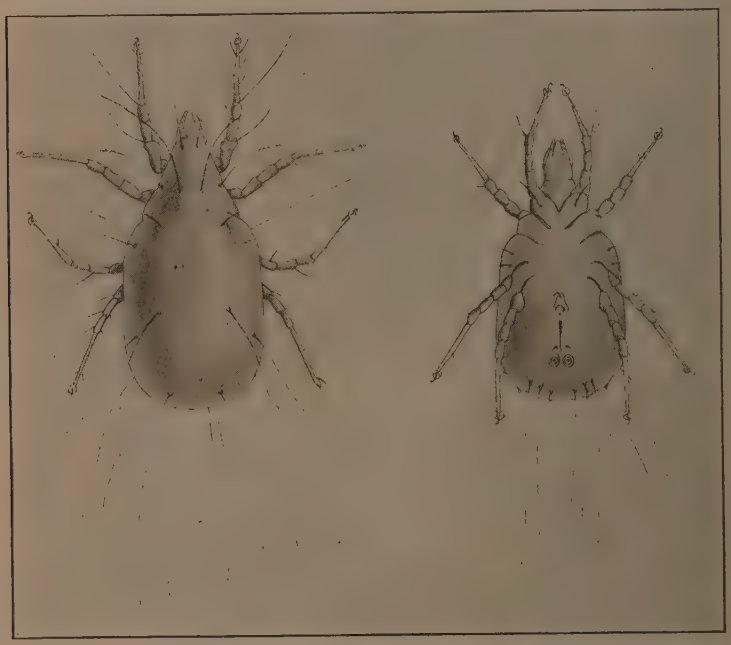

FIG. 62.—Grain mites. (Howard.)

Maryland, Delaware, Virginia, and southward, the field infestation may be much more general than is now believed. Newly thrashed wheat from Maryland arriving in September on the Baltimore market showed infestation ranging up to 6 per cent. While these infestations occurring in the grain before it is harvested are usually unavoidable, they are of great importance as "leaven" which in storage may result in a general infestation of an entire crop, in heating, and in much damage.

After grain has been harvested it is often stored in bins, storehouses, or barns that have held, or still hold, infested grain and which

have not been thoroughly cleaned. Wooden bins and wooden partitions in grain storehouses and in the holds of grain-carrying ships become the nesting places for an incredibly large number of grain pests. Certain of these can and do bore into the softer portions of the partitions and timbers that are used over and over again as dunnage, and the excavations they make serve as hiding places not only for themselves but all other species associated with them. Unless such bins and partitions are thoroughly disinfected by fumigants, these hidden insects can not be killed. The mere spraying of contact insecticides upon the walls will not reach them. If uninfested grain is placed in such bins, it naturally will become infested by the insects coming from the bin walls.

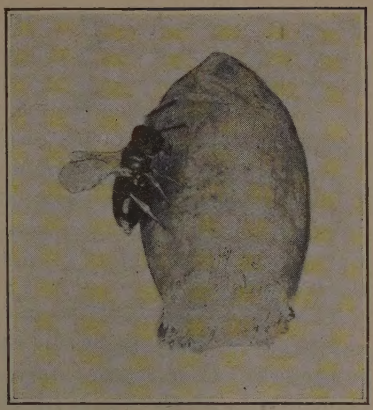

FIG. 63.—Hymenopterous parasite of grain pests. Adult parasite resting upon a kernel of wheat. These tiny gnat-like insects are beneficial but their help usually comes too late to prevent damage to the crop in which they are most abundant.

FIG. 64.—Larva of a kind of fly that preys upon grain beetles and mites. This white threadlike worm is sometimes found in grain dust and attains a length of about three-fourths of an inch; while interesting, it is of no practical value.

Likewise, uninfested grain should not be placed for shipment in sacks previously used for grain storage, for, as shown in figure 32, these old sacks often harbor insects unless they have been treated by heat or fumigation. Certain extensive and costly infestations have been traced directly to the use of secondhand untreated grain sacks.

Grain stored in the open or in poorly constructed cribs or bins may become infested by insects flying in from outside sources.

HOW TO PREVENT PRIMARY INFESTATION.

Infestation of grain in the field can not be entirely prevented, but by proper precautions it can be reduced to a minimum. The first gen-

eration of insects in the maturing grain is usually small, and if the grain is cut as soon as ripe, thrashed as soon as dry, and then placed in storage in clean, deep bins the damage from this source will be very slight. It is when the grain is left in the field long after it is ripe that serious infestation results, for the insects increase in one or two generations to enormous numbers. In the case of corn in the field, only those ears that are damaged or through poor shuck development have kernels exposed are subject to the attack of grain insects. Farmers should therefore grow a variety of corn that develops a long tight shuck.

Newly harvested small grains should not be stored unthrashed for any length of time, as in this condition they are very susceptible to infestation. If promptly thrashed and stored in deep bins, only a thin layer on top of the bin is likely to become infested. Corn may be stored in the shuck if the husk is long and tight and fully covers the tip, but all ears with loose, broken, short, or damaged husks should be shucked and stored separately.

Clean grain should never be stored in old bins, granaries, or storehouses until they have been thoroughly cleaned and freed from the accumulations of waste grain and other materials harboring grain insects. Timbers in bins, granaries, or holds of ships that have become infested with grain insects should be destroyed or treated before being used again. Steel or concrete bins are highly desirable owing to the ease with which they are cleaned.

Bags of all kinds that have previously held grain should not be allowed in granaries or warehouses or be refilled until they have been sterilized by heat or otherwise freed from insects. The use of tight cribs will keep the grain free from infestation by insects that might fly in from the outside.

THE TREATMENT OF INFESTED GRAINS.

Insects infesting stored grain can be destroyed by the use of heat, or by fumigation with poisonous gases. These remedial measures are mentioned only briefly in this bulletin.

HEAT.

A temperature of 120° to 130° F., maintained for a short time, will kill all stages of grain-infesting insects, without injuring the germinating quality of the grain. Owing to the difficulty of subjecting the grain to such a temperature this method of control is used chiefly by millers and large grain dealers who are equipped with commercial driers suitable for the purpose.

FUMIGATION.

Carbon disulphid, carbon tetrachlorid, and hydrocyanic-acid gas are the fumigants in most common use to-day for treating infested grain. Of these, carbon disulphid is the best for treating grain in bulk. It is heavier than air and if applied at the top of a gas-tight bin of grain will penetrate down through the grain, killing the insects without injury to the grain, providing it is dry. It has the one great disadvantage of being inflammable and will explode if fire in any form is brought near it. It is in general use on farms for the protection of grain in cribs (see U. S. Department of Agriculture, Farmers' Bulletins 799 and 1029.)

Carbon tetrachlorid is not as effective as carbon disulphid and costs more. For these reasons it is not in such general use. It has the great advantage of removing the fire hazard, as it is not inflammable and does not explode in presence or fire.

Hydrocyanic-acid gas is not of value in fumigating bulks of grain. When grain is stored in sacks in warehouses, heavy doses of this gas will control grain pests. This method of fumigation is discussed in Department Bulletin 872.

Fumigation with chloropicrin is not in general use at present.

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